Assessment of Productivity in the Development and Production Processes of Cricket Products and Their Impact on Thailand's Manufacturing Sector

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Abstract. *This research aims to evaluate the productivity in the development and production processes of cricket products and their impact on Thailand's production sector. The advanced statistical tools were employed to conduct an in-depth assessment of these impacts using the Computable General Equilibrium Model (CGE). This model requires a database derived from Thailand's Social Accounting Matrix (SAM). The study highlights the differences in various types of environmental costs, including energy costs, fertilizer and pesticide costs, and sanitary and similar services costs. The analysis results indicate that the development and production of cricket products affect Thailand's top 10 production sectors. The sector most impacted was Sector 105: Iron and Steel, with a Multiplier value of 3.230, a Forward Linkage value of 0.970, and a real benefit of 0.148. The second most impacted was Sector 043: Canning and Preserving of Meat, with a Multiplier value of 2.614, Forward Linkage value of 0.785, and a real benefit of 0.700. The least affected sector among the top 10 was Sector 059: Coffee and Tea, with a Multiplier value of 2.272, Forward Linkage value of 0.683, and a real benefit of 0.706. The findings suggest that strategies to mitigate the negative impacts of energy production and consumption across all activities should follow the approach outlined in this research. Since no previous studies in Thailand have investigated this topic in such a manner, this research provides a critical foundation for future strategic planning*

Keywords: cricket products, efficiency, performance evaluation, production impact, performance

1 Introduction

The increasing global population, projected to reach 9 billion by 2050, is expected to significantly raise the demand for food, particularly protein [1]. As a result, finding alternative protein sources has become critical to ensuring global food security. Crickets have emerged as a promising solution due to their high protein content and potential to serve as a sustainable substitute for conventional livestock protein [2, 3]. Crickets not only offer a sustainable protein source but also create a profitable industry for small-scale farmers, generating incomes of approximately 150,000-350,000 baht per year [4]. The Thai government has actively promoted cricket farming to boost rural income and position Thailand as a key player in the global edible insect market [5]. Crickets are relatively easy to farm, requiring minimal resources such as water, feed, and space compared to traditional livestock farming [5, 6]. They also have a lower environmental impact, making them an attractive option for addressing both food security and sustainability challenges [7, 8].

However, despite their potential, cricket farming in Thailand faces several production constraints that limit its growth, especially in terms of labor efficiency and quality control [6, 8]. The increasing demand for crickets, both domestically and globally, is not adequately met by current production methods [9, 10]. Traditional methods of drying and sanitizing cricket egg trays, such as sun-drying and gas roasting, are labor-intensive and ineffective in maintaining consistent quality and sterility [10, 11]. These limitations significantly impact productivity, leading to reduced yields and increased disease susceptibility among crickets [10, 12]. The existing production process for cricket farming can be divided into six main stages: selection of breeding stock, preparation of cricket farming ponds, preparation of clean egg trays for hiding, preparation of egg-laying trays, incubation of eggs, and harvesting [1, 13]. One of the critical issues farmers face is managing the cleanliness and sterility of the egg trays used in the rearing process. Improper cleaning can lead to the spread of diseases such as bacterial infections, viruses, and parasites, which significantly affect the crickets' health and productivity [1, 14].

Current methods, including sun-drying and gas roasting, are ineffective in eliminating all contaminants, particularly during humid conditions, and they require significant labor [1, 14, 15]. For instance, farmers need to dry thousands of trays outdoors, which is space- and time-intensive, while gas roasting is constrained by labor availability [3, 16, 17]. These constraints necessitate the development of innovative solutions to address inefficiencies in the production process. Farmers increasingly expect technology that reduces labor requirements, improves decision-making, and enhances productivity in the cricket farming process [10, 18, 19].

Therefore, cricket farming in Thailand is found to be a business that continuously consumes energy and has ongoing impacts on various sectors of the economy, including economic, social, and environmental dimensions. However, from past to present, no agencies have conducted a comprehensive analysis of these impacts. The researcher identified this research gap and thus carried

out this analysis to serve as an important tool for policy and planning development, both at the business level and the national level.

2 Material and Method

The model used in this research is applied to analyze economic impacts based on the principles of measuring direct effects, indirect effects, and induced effects. To do this, a Computable General Equilibrium (CGE) model is required, which relies on data derived from the Social Accounting Matrix (SAM). The details are as follows:

A. Structure of Environmental Cost

The assessment of inputs and outputs is a key approach used for analysis, with the details as follows:

The output of a given economic sector is the production required both as an input for intermediate producers and for final consumption by end users. The total output of any economic sector can be expressed by the following equation [20, 21]:

$$X_j = \sum_{1}^{n} x_{ij} + Y_j \tag{1}$$

From Equation (1), let a_{ij} represent the output from production sector i (out of n production sectors) that is purchased as an input for production sector j, and Y_j represent the output from production sector j that is sold to final consumers. When organizing the vectors of inputs and outputs from n production sectors into a matrix, each element of the matrix consists of [22, 23]:

$$a_{ij} = x_{ij}/Y_j \tag{2}$$

From Equation (2), the total output matrix can be written as follows:

$$X = [I - A]^{-1}Y \tag{3}$$

From Equation (3), each element of vector X represents the total output required by final consumers. This induces indirect demand for intermediate inputs from other economic sectors, including the same sector, repeatedly and sequentially, starting from the first tier of upstream demand to the second deeper tier, and so on, continuing infinitely. However, when accounting for net imports from foreign countries, the total output of an economic sector can be estimated based on the quantity of final consumption demand, under the assumption that the structural indices of goods and services imported from abroad are equivalent to those of domestic goods and services, as follows [24]:

$$X = [I - A - M]^{-1}Y \tag{4}$$

From Equation (4), let matrix M represent the structure of inputs as the value of net imports relative to the total output value of an economic sector. When the above equation for estimating the total output of an economic sector is developed into a model for assessing the total energy demand, the resulting equation is as follows [25, 26]:

$$EI = F[I - A]^{-1}Y \tag{5}$$

Each element of the EI vector represents the energy intensity index, which is the amount of energy used per unit of output for each economic sector. This includes the total accumulated energy usage throughout the entire production chain, extending to an infinite order. Each element of matrix F represents the direct energy use index for all economic sectors, classified by type of energy per unit of output for each production sector [26, 27]. The size of matrix F is determined by the number of energy types (k) multiplied by the number of production sectors (n). Therefore, when assessing the energy intensity index per unit of output for each sector in this way, it must be done with caution, because the energy use data are compiled as national accounts that include primary, secondary, and final energy consumption [24, 28]. Moreover, if every element in matrix F corresponds to energy types that, upon combustion, emit greenhouse gases, then it is possible to aggregate the total greenhouse gas emissions from the entire upstream economic system using matrix EF, which is evaluated through the following model:

$$EF = emission\ \ factor \times EI \tag{6}$$

Based on Equations (1)-(6), the researcher is able to calculate the environmental cost resulting from energy consumption and its associated impacts, as follows [25, 29]:

This study is grounded in the concept of sustainable consumption and production, with a focus on efficient and environmentally friendly production. The calculation of environmental cost is defined through four groups of environmental goods and

services, referred to as shadow environmental costs. These groups include natural resources, transportation and energy, chemical pollutants, and waste. The accumulated shadow environmental costs within the production supply chain of goods and services will be categorized by product sectors, based on the Input-Output Table of Thailand. The product sectors from the Input-Output Table will be selected specifically for the calculation of shadow environmental costs. Then, the shadow environmental cost for each sector will be computed in monetary terms [25, 26, 30].

Table 1 presents the conceptual framework for the selection of product sectors used in the shadow environmental cost calculation.

Table 1: Shadow environmental cost calculation.

Goal	Conceptual	Production and consumption activities	Shadow Environmental cost
Sustainable Development	- Welfare Economics - Natural Resource Economics - John Hartwick	External Cost Focused on Natural Capital Stock	Shadow Environmental cost - Nonnewable resources and forest - Energy and Transpotation
	- Ecological Economics	Focused on Natural Capital Stock and Min. environmental impact	- Chemical pollutants - Waste

From Table 1, the shadow environmental cost calculation is based on three main hypotheses, as follows [25, 29]:

1. The environmental cost of all production is assumed to be in a stable proportion to the quantity or value of outputs.
2. Each product sector has its own specific production chain, thus the environmental cost associated with each sector will have a different proportion.
3. All product sectors are interconnected in a network; therefore, a change in the consumption or production of one sector will lead to changes in the consumption or production of other sectors.

The following equation illustrates the relationship between environmental cost and the production of good g, based on the Input-Output Table [26].

$$\begin{bmatrix} R_{11} & \cdots & R_{1h} \\ \cdots & \cdots & \cdots \\ R_{g1} & \cdots & R_{gh} \end{bmatrix} \begin{bmatrix} X_1 \\ \cdots \\ X_i \end{bmatrix} = \begin{bmatrix} E_1 \\ \cdots \\ E_h \end{bmatrix} \tag{7}$$

From Equation (7), let R_{gh} refer to the environmental cost coefficient of product g for product sector h, where $h = i$. The results of the environmental cost calculation, categorized by sector, will reflect production-related environmental issues, such as sectors with high energy consumption or those that generate pollution. Under the concept of Sustainable Production and Consumption, attention is given to the Green Value Added of each production sector, which represents the net production profit after accounting for environmental costs. The environmental costs calculation comprises three key components: The environmental costs of each product sector; the green value added of the production sector; and the Multiplier effect. This information will be valuable for policy formulation and environmental management. The conceptual framework for calculating shadow environmental cost is rooted in the principles of sustainable consumption and production.

B. Steps for Assessing Impacts Using the CGE Model

The economic impact assessment using the Social Accounting Matrix (SAM) and the Computable General Equilibrium (CGE) Model involves the following key steps [24, 25, 29, 30]:

Step 1: Database Preparation

This step involves updating the Social Accounting Matrix (SAM) using data from the Input-Output Table of Thailand's Digital Economy Sector in 2017, which marks the initial year of investment spending in telecommunications infrastructure. The transformation of the Input-Output Table into a SAM framework for Thailand's digital economy relies on the production structure developed by Professor David Roland-Holst of the University of California, Berkeley, which is further adapted from the SAM database of TDRI (Thailand Development Research Institute).

Step 2: Adjustment of the Computable General Equilibrium (CGE) Model

The CGE model is modified to reflect and simulate economic impacts. The adjustment process includes:

1. Identifying the sectors-including business sectors, households, and institutions, that are expected to be affected by infrastructure investment and related spending.

2. Determining positions within the SAM to reflect spending changes resulting from infrastructure investment. These key positions are:

Position 1: Investment in mega projects injected into the infrastructure sector, which is designated as the 16th sector in the model. The investment value is compared with the initial (baseline) value of the infrastructure sector.

Position 2: Public budget spending, where government expenditures are increased due to additional budget from investment funds beyond the annual budget. This change is calculated in proportion to the total government budget.

3. Economic Impact Assessment

The economic impact assessment can be conducted through the following steps:

Step 1: Identify the value of infrastructure investment, and input this value into the designated positions within the model.

Step 2: Identify the additional government budget received, and input it into the designated positions accordingly. After that, calculate the Direct Effect, Indirect Effect, and Induced Effect resulting from these changes, as follows:

3 Empirical Analysis

Based on the analysis titled "Assessment of Productivity in the Development and Production Processes of Cricket Products and Their Impact on Thailand's Manufacturing Sector," the study examined two key aspects: Multiplier Analysis, where it involved assessing the connectivity between the marginal unit of final demand in each production sector and GDP growth; and Green Value Added Analysis, in which it aimed to identify the difference between the sector's value added and the gross cost of natural resources and environmental impact generated by each production sector.

The analysis was conducted using environmental cost data categorized by production sectors (Codes 001 to 180). It involved comparing the environmental and natural resource costs and ranking the significance of each sector based on multiplier value, value added, and the deducted cost of natural resources and environmental impact. The findings revealed the average real benefit across sectors is 0.709. The average environmental costs were broken down as follows: Natural Resource Materials: 0.0276; Energy and Transportation: 0.119; Fertilizer and Pesticides: 0.006; and Sanitary and Similar Services: 0.001. Analysis Results of the Real Benefit from the Production and Manufacturing Processes of Cricket Products

The analysis of real benefits, after deducting environmental costs, within the manufacturing sector presents detailed findings across 180 sectors in Thailand, as follows:

Table 2: The results of the real benefits analysis after deduct the environmental costs

Code	Product Sector Name (180 sectors)	Real Benefit	Total Cost	Multiplier	Forward Linkage
1	Paddy	0.749	0.072	1.274	0.383
2	Maize	0.747	0.109	1.496	0.45
3	Other cereals	0.865	0.06	1.445	0.434
4	Cassava	0.775	0.108	1.633	0.491
5	Other root crops	0.606	0.087	1.368	0.411
6	Beans and nuts	0.676	0.127	1.489	0.447
7	Vegetable	0.732	0.115	1.545	0.464
8	Fruits	0.731	0.084	1.406	0.422
9	Sugar cane	0.769	0.104	1.556	0.468
10	Coconut	0.941	0.035	1.161	0.349
11	Oil palm	0.564	0.261	1.587	0.477
12	Kenaf and jute	0.798	0.108	1.465	0.44
13	Other crops for textile and matting	0.792	0.129	1.629	0.489
14	Tobacco	0.731	0.139	1.587	0.477
15	Coffee and tea	0.633	0.218	1.732	0.52
16	Rubber	0.872	0.049	1.158	0.348
17	Other agricultural product	0.766	0.121	1.471	0.442
18	Cattle and buffalo	0.883	0.039	1.322	0.397
19	Swine	0.667	0.099	2.29	0.688
20	Other livestock	0.813	0.036	1.467	0.441
21	Poultry	0.694	0.075	2.025	0.608
22	Poultry products	0.613	0.118	2.13	0.64
23	Silk worm	0.873	0.069	1.6	0.481
24	Agricultural services	0.5	0.249	1.463	0.44
25	Logging	0.878	0.04	1.33	0.4

Table 2 Continued: The results of the real benefits analysis after deduct the environmental costs

Code	Product Sector Name (180 sectors)	Real Benefit	Total Cost	Multiplier	Forward Linkage
26	Charcoal and fire-wood	0.855	0.1	1.284	0.386
27	Other forest products	0.84	0.072	1.301	0.391
28	Ocean and coastal fishing	0.563	0.189	1.579	0.474
29	Inland fishing	0.694	0.112	1.787	0.537
30	Coal and lignite	0.501	0.324	1.495	0.449
31	Petroleum and natural gas	0.71	0.167	1.5	0.451
32	Iron ore	0.64	0.054	1.665	0.5
33	Tin ore	0.462	0.278	1.617	0.486
34	Tungsten ore	0.452	0.17	1.668	0.501
35	Other non-ferrous metals	0.716	0.143	1.47	0.442
36	Fluorite	0.321	0.475	1.787	0.537
37	Chemical fertilizers	0.767	0.12	1.479	0.444
38	Salt	0.886	0.075	1.249	0.375
39	Limestone	0.825	0.032	1.378	0.414
40	Stone quarrying	0.61	0.191	1.613	0.485
41	Other mining and quarrying	0.494	0.316	1.567	0.471
42	Slaughtering	0.741	0.092	1.541	0.463
43	Canning and preserving of meat	0.7	0.131	1.65	0.496
44	Dairy products	0.667	0.105	2.011	0.604
45	Canning and preservation of fruit and vegetables	0.632	0.13	1.976	0.594
46	Canning and preservation of fish and other sea foods	0.479	0.12	1.842	0.553
47	Coconut and palm oil	0.568	0.25	2.401	0.721
48	Animal oil, animal fat, vegetable oil and by-products	0.191	0.051	1.247	0.375
49	Rice milling	0.722	0.121	2.1	0.631
50	Tapioca milling	0.673	0.187	1.484	0.446
51	Grinding of maize	0.749	0.129	2.128	0.639
52	Flour and other grain milling	0.476	0.091	1.908	0.573
53	Bakery products	0.499	0.108	1.921	0.577
54	Noodles and similar products	0.587	0.154	2.257	0.678
55	Sugar	0.743	0.129	1.861	0.559
56	Confectionery	0.646	0.139	2.108	0.633
57	Ice	0.249	0.541	1.803	0.542
58	Monosodium glutamate	0.585	0.211	2.15	0.646
59	Coffee and tea	0.706	0.097	2.272	0.683
60	Other food products	0.634	0.105	1.749	0.526
61	Animal feed	0.386	0.083	1.636	0.491
62	Distilling and spirits blending	0.793	0.084	1.62	0.487
63	Breweries	0.771	0.052	1.402	0.421
64	Soft drinks and carbonated water	0.594	0.1	1.75	0.526
65	Tobacco processing	0.805	0.113	1.839	0.553
66	Tobacco products	0.921	0.021	1.218	0.366
67	Spinning	0.347	0.208	1.768	0.531
68	Weaving	0.452	0.252	1.847	0.555
69	Textile bleaching, printing and finishing	0.287	0.242	1.749	0.525
70	Made-up textile goods	0.499	0.17	1.889	0.567
71	Knitting	0.476	0.108	1.76	0.529
72	Wearing apparel	0.561	0.176	2.075	0.624
73	Carpets and rugs	0.558	0.171	2.108	0.633
74	Jute mill products	0.599	0.047	1.549	0.465
75	Tanneries and leather finishing	0.392	0.041	1.477	0.444
76	Leather products	0.616	0.076	1.679	0.504
77	Footwear, except of rubber	0.618	0.106	1.835	0.551
78	Saw mills	0.449	0.359	1.758	0.528
79	wood and cork products	0.592	0.251	1.98	0.595
80	Wooden furniture and fixtures	0.588	0.114	1.638	0.492

Table 2 Continued: The results of the real benefits analysis after deduct the environmental costs

Code	Product Sector Name (180 sectors)	Real Benefit	Total Cost	Multiplier	Forward Linkage
81	Pulp, paper and paperboard	0.508	0.129	1.497	0.45
82	Paper and paperboard products	0.385	0.082	1.52	0.457
83	Printing and publishing	0.528	0.087	1.648	0.495
84	Basic industrial chemicals	0.379	0.166	1.412	0.424
85	Fertilizer and pesticides	0.329	0.107	1.422	0.427
86	Petrochemical products	0.38	0.213	1.54	0.463
87	Paints	0.204	0.481	2.292	0.689
88	Drugs and medicines	0.567	0.087	1.591	0.478
89	Soap and cleaning preparations	0.432	0.091	1.599	0.48
90	Cosmetic	0.444	0.132	1.574	0.473
91	Matches	0.599	0.168	1.73	0.52
92	Other chemical products	0.419	0.127	1.496	0.45
93	Petroleum refineries	0.166	0.035	1.054	0.317
94	Other petroleum products	0.457	0.079	1.743	0.524
95	Rubber sheet and block rubber	0.775	0.079	1.947	0.585
96	Types and tubes	0.473	0.153	1.757	0.528
97	Other rubber products	0.584	0.115	1.799	0.54
98	Plastic ware	0.369	0.203	1.827	0.549
99	Ceramic and earthen ware	0.383	0.346	1.85	0.556
100	Glass and glass products	0.303	0.288	1.766	0.531
101	Structural clay products	0.293	0.427	1.952	0.587
102	Cement	0.316	0.443	2.614	0.785
103	Concrete and cement products	0.414	0.31	1.843	0.554
104	Other non-metallic products	0.359	0.399	2.015	0.605
105	Iron and steel	0.148	0.556	3.23	0.97
106	Secondary steel products	0.283	0.188	1.682	0.505
107	Non-ferrous metal	0.229	0.2	1.341	0.403
108	Cutlery and hand tools	0.413	0.071	1.371	0.412
109	Metal furniture and fixtures	0.337	0.068	1.439	0.432
110	Structure metal products	0.397	0.068	1.352	0.406
111	Other fabricated metal products	0.347	0.079	1.375	0.413
112	Engines and turbines	0.421	0.098	1.743	0.524
113	Agricultural machinery and equipment	0.455	0.107	1.528	0.459
114	Wood and metal working machines	0.344	0.094	1.516	0.456
115	Special industrial machinery	0.378	0.102	1.495	0.449
116	Office and household machinery and appliances	0.374	0.055	2.427	0.729
117	Electrical industrial machinery and appliances	0.283	0.059	1.297	0.39
118	Radio, television and communication equipment and apparatus	0.141	0.026	1.115	0.335
119	Household electrical appliances	0.316	0.096	1.542	0.463
120	Insulated wire and cable	0.427	0.064	1.333	0.4
121	Electric accumulators and batteries	0.386	0.106	1.504	0.452
122	Other electrical apparatus and supplies	0.415	0.094	1.765	0.53
123	Motor vehicles	0.54	0.113	1.726	0.518
124	Motor vehicles	0.429	0.176	1.956	0.588
125	Repair of motor vehicles	0.332	0.074	2.532	0.761
126	Ship building and repairing	0.428	0.096	1.847	0.555
127	Railroad equipment	0.466	0.087	1.586	0.477
128	Aircraft	0.368	0.06	1.265	0.38
129	Scientific equipment	0.265	0.056	1.299	0.39
130	Photographic and optical goods	0.594	0.072	1.457	0.438
131	Watches and clocks	0.518	0.069	1.517	0.456
132	Jewelry and related articles	0.316	0.068	1.357	0.408

Table 2 Continued: The results of the real benefits analysis after deduct the environmental costs

Code	Product Sector Name (180 sectors)	Real Benefit	Total Cost	Multiplier	Forward Linkage
133	Recreational and athletic equipment	0.535	0.126	1.872	0.562
134	Other manufactured goods	0.509	0.105	1.672	0.502
135	Electricity	0.298	0.434	1.618	0.486
136	Pipe line and gas distribution	-0.043	0.94	2.281	0.685
137	Water work and supply	0.643	0.257	1.492	0.448
138	Residential building construction	0.344	0.233	1.887	0.567
139	Non-residential building construction	0.287	0.283	2.003	0.602
140	Public works for agriculture and forestry	0.553	0.216	1.696	0.509
141	Non-agriculture public works	0.295	0.409	2.021	0.607
142	Construction of electric plants	0.229	0.24	1.668	0.501
143	Construction of communication facilities	0.49	0.101	1.45	0.436
144	Other construction	0.584	0.166	1.682	0.505
145	Wholesale trade	0.874	0.075	1.33	0.4
146	Retail trade	0.886	0.068	1.287	0.387
147	Restaurants and drinking places	0.69	0.15	1.958	0.588
148	Hotels and places of loading	0.45	0.369	1.926	0.579
149	Railways	0.48	0.228	1.588	0.477
150	Road passenger transport	0.301	0.319	1.923	0.578
151	Road freight transport	0.211	0.369	1.977	0.594
152	Land transport support service	0.901	0.053	1.281	0.385
153	Ocean transport	0.241	0.271	1.675	0.503
154	Coastal and inland water transport	0.429	0.287	1.549	0.466
155	Water transport services	0.734	0.133	1.42	0.427
156	Air transport	0.238	0.427	1.848	0.555
157	Other services	0.708	0.171	1.7	0.511
158	Storage and warehousing	0.582	0.312	1.663	0.5
159	Post and telecommunication	0.822	0.107	1.64	0.493
160	Banking services	0.868	0.07	1.504	0.452
161	Life insurance services	0.88	0.069	1.318	0.396
162	Other Insurance Service	0.89	0.061	1.324	0.398
163	Real-estate	0.903	0.071	1.228	0.369
164	Business services	0.702	0.125	2.161	0.649
165	Public administration	1	-	1	0.3
166	Sanitary and similar services	0.73	0.134	1.454	0.437
167	Education	0.832	0.091	1.33	0.399
168	Research	0.774	0.098	1.457	0.438
169	Hospital	0.611	0.129	1.529	0.459
170	Business and labor associations	0.741	0.149	1.494	0.449
171	Other community service	0.789	0.128	1.348	0.405
172	Movie theatres	0.487	0.118	1.895	0.569
173	Movie theatres	0.577	0.16	2.302	0.692
174	Radio, television and related services	0.721	0.128	1.992	0.599
175	Libraries and museums	0.833	0.072	1.446	0.434
176	Amusement and recreation	0.81	0.1	1.38	0.415
177	Repair not classified elsewhere	0.429	0.096	1.704	0.512
178	Personal service	0.607	0.164	1.496	0.45
179	Other service not classified elsewhere	-	-	1	0.3
180	Unclassified	0.461	0.208	1.952	0.586

In addition, Table 2 also presents the top 10 sectors based on environmental issue indicators. The findings show that the production sector that has the highest environmental issues was sector 105 Iron and steel sector which Multiplier value equals to 3.230 and Forward Linkage Value equal to 0.970 , followed by 043: Canning and preserving of meat sector which Multiplier value equals to 2.614 and Forward Linkage Value equal to 0.785, 042: Slaughtering sector which Multiplier value equals to 2.532 and Forward Linkage Value equal to 0.761, 050: Tapioca milling sector which Multiplier value equals to 2.427 and Forward Linkage Value equal to 0.729, 047: Coconut and palm oil sector which Multiplier value equals to 2.401 and Forward Linkage Value equal to 0.721, 173: Movie theatres sector which Multiplier value equals to 2.302 and Forward Linkage Value equal to 0.692, 180: Unclassified sector which Multiplier value equals to 2.290 and Forward Linkage Value equal to 0.689, 019: Swine sector which Multiplier value equals to 2.290 and Forward Linkage Value equal to 0.688, 054: Noodles and similar products sector which Multiplier value equals to 2.281 and Forward Linkage Value equal to 0.685, and 059: Coffee and tea sector which Multiplier value equals to 2.272 and Forward Linkage Value equal to 0.683.

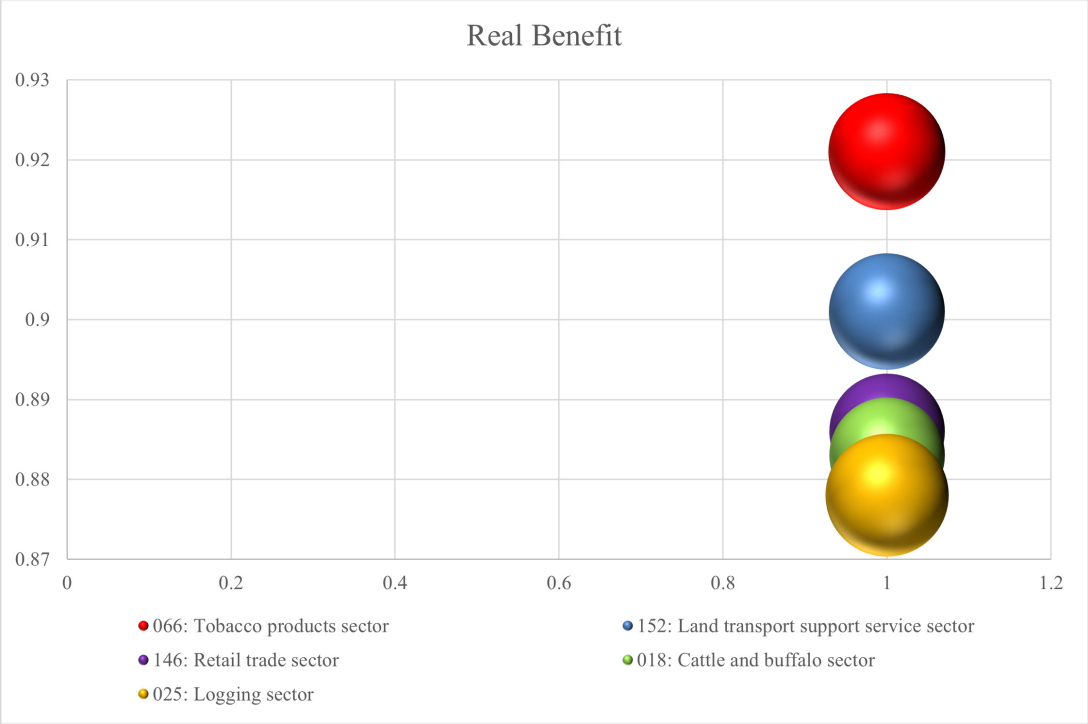


Figure 1: The ranking of impacts affecting real benefits.

According to Table 2, which presents the analysis results of the impact on changes in real benefits, total cost, multiplier, and forward linkage, it was found that each sector differs. Therefore, for effective and efficient management strategy formulation, it is essential to evaluate the priority rankings from 1 to 10 that contribute the most to real benefits. This information can then be used to support national policy and planning. From Figure 1, it is shown that the top 10 sectors in terms of real benefits are as follows: Sector 010: Coconut sector, with a real benefit value of 0.941; Sector 066: Tobacco products sector, with a value of 0.921; Sector 163: Real estate sector, with a value of 0.903; Sector 152: Land transport support services, with a value of 0.901; Sector 162: Other insurance services, with a value of 0.890; Sector 146: Retail trade, with a value of 0.886; Sector 038: Salt sector, with a value of 0.886; Sector 018: Cattle and buffalo sector, with a value of 0.883; Sector 161: Life insurance services, with a value of 0.880; and Sector 025: Logging sector, with a value of 0.878.

4 Discussion and Conclusion

This research demonstrates that Thailand's rapid economic growth policy has led to significant expansion in certain business sectors. The government specified 10 business sectors ought to support and develop sustainably that can be competitive in the global economy. 10 business sectors consist of Pipe line and gas distribution, Iron and Steel, oil palm, Coffee and Tea, Repair of motor vehicles, Office and household machinery and appliances, Construction Material, Fluorite, Movie Theatres, and Hotels and places of loading. According to the information form NESDB [5] and ADB [15] found that these sectors generate a huge income to the country and stimulate the economics of Thailand continuously until present. Moreover, these sectors create jobs to labors. Therefore, if Thailand maintain business supporting level to these business sectors and expand to other business sectors, it will bring the economic growth of the country.

This research studied the cost, covered Natural Resources Materials, Energy and Transportation, Fertilizer and Pesticides, and Sanitary and Similar Service, of each sector. Besides, the researcher calculated the real benefit and Multiplier to illustrate the environmental problem from each sector that the government must resolve immediately if the production is over carrying capacity. If the government abandons these problems, it could lead to negative impact to the state in the future. The research result of each government supporting sector found that:

1. Pipeline and gas distribution sector is the sector that government keeps supporting for long time [5, 18]. However, the study of this research found that Pipeline and gas distribution has the highest Natural Resources Materials cost and higher than the average value. Accordingly, the real benefit of this sector is low. Moreover, the study found that this sector face with the environmental problem ranked in the 9th from 10 sectors [5]. Thus, the government should solve the problem urgently that they might implement Pollution Pay Principle tax strictly.

2. The government support many policies in Iron and steel sector to generate income to the country because it could bring Thailand leading in this business sector in global market in short time [5, 15]. The research found that Iron and steel has the highest cost of Energy and Transportation, which led the real benefit of this sector low. Furthermore, it is facing with the highest environmental problem that the government should take care firstly with proactive and reactive strategy. Proactive measurement is growing awareness of using resources that friendly to environmental and natural resources, whereas reactive measurement is to strictly implement law and tax, which the tax of this sector should be high because the government must monitor closely to this sector resulting in decreasing negative impact to the country [5, 15, 18].

3. Oil Palm is the sector that the government keep promote and support agriculturist to do a job in this sector in order to get market share from Vietnam [5]. From the research, nonetheless, found that Oil palm sector contributes the highest impact to Fertilizer and Pesticides, which is the main cause of low real benefit of this sector. Moreover, when consider related sector, which is Coconut and palm oil, found that this sector has the environmental problem in 5th rank. Thus, the government needs to give an importance to this sector because it could bring to ecological losing constantly that could not adjust later. Polluters Pay Principle law is the measures to create awareness among agriculturist in this sector [5, 15].

4. Repair of motor vehicles is the sector that the government promoting consecutively by established specific department to analyze situation and strategy to competitive in the global market. However, this sector has the highest environmental problem in Natural Resources Material in 3rd rank and environmental cost of Energy and Transportation in 2nd rank. Both of factors are the key causes of low Real Benefit of this sector as well as the highest environmental problem in 3rd rank. Therefore, the government must give priority to environmental problem, which the government should see in two sides that are supporting side and resolving side. Then, they should develop and manage environmental problem contributing less effect to environment or minimize waste [5, 15].

5. Office and household machinery and appliances sector, Thailand is the top exporter and having the highest market share in Southeast Asia. Nevertheless, this research found that this sector did not create high real benefit to Thailand because this sector has high cost in every type of environmental cost. Additionally, they are in 3rd highest rank in environmental problem that the government is necessary to control and do strategy to re-promote to lead to high real benefit of this sector with the same proportion with exporting level.

6. Thailand has the highest market share in the global in Construction Material sector because of high product quality. From the research found that 085: Paints is the second highest, 102: Cement is the fourth highest, and Structural clay products is the fifth highest in environmental cost in Natural Resources Material, which led to low real benefit to this sector. Moreover, this sector contributes many environmental problems such as 102: Cement. Therefore, the government should find the solution in proactive, reactive and corrective such as applying Clean Technology with this sector and increasing penalty.

7. Thailand experts in Fluorite manufacturing sector that generated income to Thailand repetitively. However, this research found that this sector has high Energy and Transportation cost in 3rd rank leading to low real benefit. Although the government kept supporting and specialized in this sector, but this sector also has high environmental cost and affect to ecology. Therefore, the government should give significance because it could bring to over carrying capacity manufacturing.

8. NESDB [5] stated that Coffee and Tea is the sector that the government encourage and assist to increase agriculturists to join in this sector and increase exporting level which 80% of production is exporting. The main competitors are Vietnam and India. However, the research illustrated that Coffee and Tea is the 3rd highest in environmental effect from Fertilizer and Pesticides, which is the cause of low real benefit of this sector and environmental problem in 10th rank. Thus, the government must monitor this sector closely because this sector could bring loss in ecological continuously that possibly cannot resolve late. Polluters Pay Principle law is the measures to create awareness among agriculturist in this sector.

9. Movie Theatres is the sector that Thailand tries to do marketing in order to let other countries know about Thailand and generate high income to the country. However, from this study found that this sector has the highest Sanitary and Similar Service cost and low real benefit. Besides, it has high environmental problem in 6th rank. Seeing that the government ought to issue urgent measures to monitor closely and penalize offenders seriously.

10. Hotels and places of loading is the sector generates high income to Thailand that the government keeps supporting that led to Thailand recognized by many foreigners. Therefore, there are many Thai and foreign travelers receive this service that it helps to increase current fund in the economic system. With the 2nd highest in Sanitary and Similar Service cost, the government must find the solution immediately in proactive, reactive, corrective and conservation measures because it might difficult to resolve

later if they ignore to do.

11. Coconut, Tobacco products, Real estate, and transport support service are the highest first 4-rank in Real Benefit with high value because they have low environmental cost on all sectors. Thus, the government must keep supporting and promoting to develop continuously by implementing measures to stimulate such as reducing tax payment, giving supporting capital, supporting tools and Green Technology. However, from this research and related studies found that they have the highest Real Benefit and high environmental cost that the government must catch up watchfully as well as find efficient management method and sustainable development.

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